QUANTUM

HIGH FREQUENCY X-RAY GENERATOR

Operator's Manual

Quantum
MEDICAL IMAGING

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QUANTUM

HIGH FREQUENCY X-RAY GENERATOR

Operator's, Installation and Service Manual

Quantum MEDICAL IMAGING

Address any questions regarding X-ray generator operation to:

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Telephone:	(631) 567-5800
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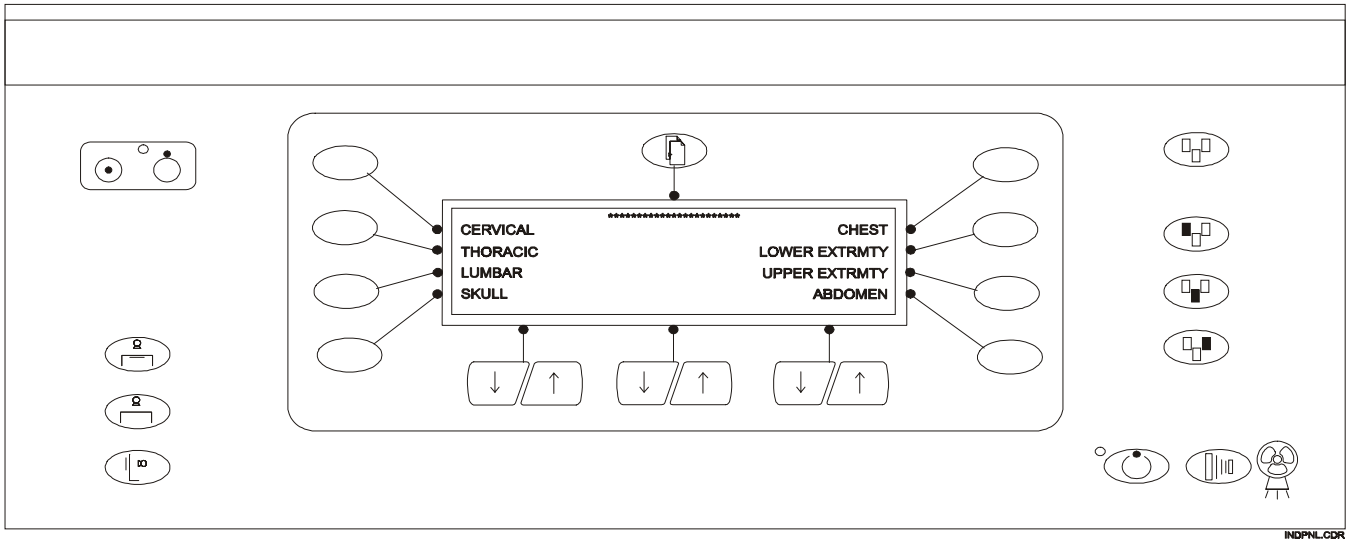
X-RAY GENERATOR



OPERATOR'S MANUAL

The original version of this manual (26 July 1999)
has been drafted in the English language by:
Communications & Power Industries Inc.
communications & medical products division.

OPERATOR'S MANUAL P/N 740916-00

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OPERATOR'S MANUAL

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INTRODUCTION 1

This high frequency X-ray generator features state-of-the-art computer-based control to ensure minimum patient dose, excellent reproducibility, and superior image contrast. The operator control functions are designed to be simple and user-friendly.

The optional AEC (Automatic Exposure Control) feature gives you controlled exposure factors, automatically optimized for the radiological study selected.

GENERATOR MAIN FEATURES

- 150 kVp output capability (125 kVp maximum for some models).
- Smaller, lighter modular design.
- Constant dose output due to kVp and mA regulation during exposures.
- User-friendly controls.
- Large LCD panel display for APR and utility routines.
- User-friendly system configuration.
- APR techniques may be modified by the operator.
- Extensive self-diagnostics with operator prompt messages.
- Programmed for APR operation, with manual override of technique factors.

OPTIONS

- Optional AEC. Interfaces with 2 A.I.D. ion chambers

SAFETY NOTICE:	***This manual contains important safety information. An understanding of this information is critical to the safe operation of your equipment. Please ensure that you read the warning notices before using the equipment.***

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SAFETY AND SPECIFICATIONS 2

Keep this operator's manual with the equipment at all times, and periodically review the operating and safety instructions.

SAFETY / WARNING SYMBOLS

		Warning symbol used to indicate a potential hazard to operators, service personnel or to the equipment. It indicates a requirement to refer to the accompanying documentation for details.
		Radiation exposure symbol used on operator console. Lights to indicate that an exposure is in progress. This is accompanied by an audible tone from the console.
WARNING	*THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.*	Radiation warning label on console. Never allow unqualified personnel to operate the X-ray generator.

WARNING: ***PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO X-RAY GENERATORS ARE THE RESPONSIBILITY OF THE USERS OF SUCH GENERATORS. CPI CANADA INC. PROVIDES INFORMATION ON ITS PRODUCTS AND ASSOCIATED HAZARDS, BUT ASSUMES NO RESPONSIBILITIES FOR AFTER-SALE OPERATING AND SAFETY PRACTICES.***

CPI CANADA INC. ACCEPTS NO RESPONSIBILITY FOR ANY GENERATOR NOT MAINTAINED OR SERVICED ACCORDING TO THE SERVICE AND INSTALLATION MANUAL OR ANY GENERATOR THAT HAS BEEN MODIFIED IN ANY WAY.

CPI CANADA INC. ALSO ASSUMES NO RESPONSIBILITY FOR X-RAY RADIATION OVEREXPOSURE OF PATIENTS OR PERSONNEL RESULTING FROM POOR OPERATING TECHNIQUES OR PROCEDURES.

WARNING: ***THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.***

CAUTION: ***DO NOT EXCEED THE TUBE MAXIMUM OPERATING LIMITS SHOWN IN THE X-RAY TUBE DATA SECTION AT THE END OF THE OPERATOR'S MANUAL. INTENDED LIFE AND RELIABILITY WILL NOT BE OBTAINED UNLESS GENERATORS ARE OPERATED WITHIN PUBLISHED SPECIFICATIONS.***

X-ray radiation exposure may be damaging to health, with some effects being cumulative and extending over periods of many months or even years. **X-ray operators should avoid any exposure to the primary beam** and take protective measures to safeguard against scatter radiation. Scatter radiation is caused by any object in the path of the primary beam and may be of equal or less intensity than the primary beam that exposes the film.

No practical design can incorporate complete protection for operators or service personnel who do not take adequate safety precautions. **Only authorized and properly trained service and operating personnel should be allowed to work with this X-ray generator equipment.** The appropriate personnel must be made aware of the inherent dangers associated with the servicing of high voltage equipment and the danger of excessive exposure to X-ray radiation during system operation.

- Wear protective clothing. Protective aprons with an equivalent of a minimum of 1/64" (0.35 mm) of lead are recommended.
- To protect the patient against radiation, always use radiation protection accessories in addition to devices which are fitted to the X-ray equipment.
- Keep as large a distance as possible away from the object being exposed and the X-ray tube assembly.
- Never operate this X-ray equipment in areas where there is a risk of explosion. Detergents and disinfectants, including those used on patients, may create explosive mixtures of gases. Please observe the relevant regulations.
- The operator console, or anything electrically connected to it, must never be used within 6 ft (1.8 m) of the patient environment.
- Do not place liquids (coffee, beverages, flowers, etc) on the control console or generator main cabinet.
- Do not operate the console in an inclined or vertical position. It is designed to be operated in a horizontal position only.
- Always ensure adequate ventilation around the control console and generator main cabinet. Do not operate the equipment near curtains, drapes, etc which may block the ventilation slots. Do not place the console on rugs, blankets, etc, which may obstruct cooling.
- Do not operate the console or generator main cabinet in direct sunlight or near any heat sources.
- Do not operate the console near strong magnetic fields (microwave ovens, speakers, etc), and avoid routing the console cables near these devices.
- The console and generator main cabinet must be operated in locations that are clean (free of excess dust, dirt, debris, etc), stable (free of vibration), and secure such that the console cannot slip or tip.
- Only trained maintenance staff may remove the covers of the generator cabinet and the control console.

Do not connect unapproved equipment to the rear of the console. J1 and J12 on the CPU board are used for interconnect cables to the generator main cabinet. J1 and J2 on the optional AEC board are the AEC inputs from the AEC chamber(s). J5 and J6 are CAEC inputs ONLY.

INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE.

APPLICABLE STANDARDS

This series of X-ray generators complies with some or all of the following regulatory and design standards as indicated in the table at the bottom of this page.

1) UL187.

2) FDA Center for Devices & Radiological Health (CDRH) - 21 CFR subchapter J (USA).

3) Radiation Emitting Devices Act - C34 (Canada).

4) EC Directive 93/42/EEC concerning Medical Devices (European Community).

5) IEC 601.1, IEC 601.2.7:1998, CSA 601.1, UL2601.1.
-Type of protection against electric shock: Class I equipment.
-Degree of protection against electric shock: Not classified.
-Degree of protection against harmful ingress of water: Ordinary equipment.
-Mode of operation: Continuous operation with intermittent loading (standby - exposure).
-Equipment not suitable for use in presence of a FLAMMABLE ANESTHETIC MIXTURE WITH AIR OR WITH OXYGEN OR NITROUS OXIDE.

6) IEC 601.1.2.
Immunity:

IEC1000-4-2	Electrostatic discharge
IEC1000-4-3	Radiated RF field
IEC1000-4-4	Electrical fast transient
IEC1000-4-5	Surge
IEC1000-4-6	Conducted RF immunity
IEC1000-4-8	Magnetic field immunity
IEC1000-4-11	Voltage dips, interrupts and variations

Emission:
EN55011 (CISPR Publications 11 Emission Standards, Group 1 Class A).

REGULATORY STANDARD	30 kW	32.5 kW	37.5 kW	50 kW
1) UL187.	√	√	√	
2) FDA Center for Devices & Radiological Health (CDRH) - 21 CFR subchapter J (USA).	√	√	√	√
3) Radiation Emitting Devices Act - C34 (Canada).	√	√	√	√
4) EC Directive 93/42/EEC concerning Medical Devices (European Community).				√
5) IEC 601.1, IEC 601.2.7:1998, CSA 601.1, UL2601.1.				√
6) IEC 601.1.2, CISPR 11.				√

ELECTROMAGNETIC COMPATIBILITY (EMC)

In accordance with the intended use, some models of this series of X-ray generators complies with the European Council Directive concerning Medical Devices as per the table on the previous page. The CE marking affixed to this product signifies this. One of the harmonized standards of this Directive defines the permitted levels of electromagnetic emission from this equipment and its required immunity from the electromagnetic emissions of other devices.

It is not possible, however, to exclude with absolute certainty the possibility that other high frequency electronic equipment, which is fully compliant to the EMC regulations, will not adversely affect the operation of this generator. If the other equipment has a comparatively high level of transmission power and is in close proximity to the generator, these EMC concerns (the risk of interference) may be more pronounced. It is therefore recommended that the operation of equipment of this type such as mobile telephones, cordless microphones and other similar mobile radio equipment be restricted from the vicinity of this X-ray generator.

OUTPUT PARAMETERS

kVp range:	40 to 150 kVp output capability (125 kVp maximum for some models).
kVp steps:	variable in 1 kVp steps.
kVp accuracy:	± 5 %.
Ripple (kV):	5 % p-p over the full operating range.
Risetime (10-90%):	<1.5 ms.
Time range:	0.004 - 6 seconds.
mAs range:	1.0 to 420 mAs (large focus), 0.1 to 100 mAs (small focus) for 30, 32.5, and 37.5 kW generators 1.0 to 600 mAs (large focus), 0.1 to 100 mAs (small focus) for 50 kW generators.
mAs accuracy:	± (10 % + 0.2) mAs.
mA range:	25 to 300 mA (30 kW generators), 25 to 325 mA (32.5 kW generators), 25 to 375 mA (37.5 kW generators), 25 to 500 mA (50 kW generators).
Coefficient of linearity:	0.05 (station to station) mAs.
Coefficient of reproducibility:	kV, mAs ≤ 0.04.
Lowest current – time product:	0.1 mAs.
Loading factors which will allow lowest current - time product:	Refer to table 1 in section 6.

OUTPUT PARAMETERS (CONTINUED)

OUTPUT PARAMETER	GENERATOR SERIES	LOADING FACTOR
Maximum X-ray tube voltage and highest X-ray tube current at that voltage (125 kV generators)	50 kW 37.5 kW 32.5 kW 30 kW	125 kV, 400 mA 125 kV, 300 mA 125 kV, 250 mA 125 kV, 225 mA
Maximum X-ray tube voltage and highest X-ray tube current at that voltage (150 kV generators)	50 kW 37.5 kW 32.5 kW 30 kW	150 kV, 325 mA 150 kV, 250 mA 150 kV, 200 mA 150 kV, 200 mA
Maximum X-ray tube current and highest X-ray tube voltage at that current (125 kV and 150 kV generators)	50 kW 37.5 kW 32.5 kW 30 kW	500 mA, 100 kV 375 mA, 100 kV 325 mA, 100 kV 300 mA, 100 kV
Combination of X-ray tube current and X-ray tube voltage resulting in highest output power	50 kW 37.5 kW 32.5 kW 30 kW	500 mA, 100 kV 375 mA, 100 kV 325 mA, 100 kV 300 mA, 100 kV
Highest constant output power at 100 kV, 0.1 sec	50 kW 37.5 kW 32.5 kW 30 kW	50 kW (500 mA, 100 kV, 0.1 s) 37.5 kW (375 mA, 100 kV, 0.1 s) 32.5 kW (325 mA, 100 kV, 0.1 s) 30 kW (300 mA, 100 kV, 0.1 s)
Nominal shortest irradiation time (AEC exposures)	All models	10 ms

ENVIRONMENTAL SPECIFICATIONS

OPERATING

Ambient temperature range	10 to 40 °C (50 to 104 °F).
Relative humidity	20 to 80%, non condensing.
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg).

TRANSPORT AND STORAGE

Ambient temperature range	-25 to 70 °C (-13 to 158 °F)..
Relative humidity	5 to 95%, non condensing.
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg).

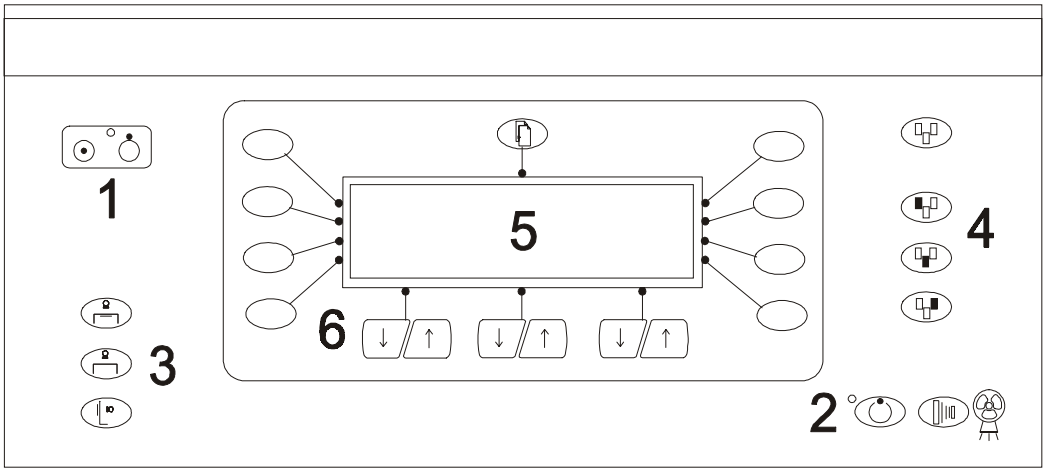
This information is provided to help you establish safe operating conditions for both you and your X-ray generator.

Do not operate this X-ray generator except in accordance with information included in this section, and any additional information provided by the X-ray generator manufacturer and / or competent safety authorities.

Any questions regarding X-ray generator operation should be directed to the Customer Support Department as shown on the inside cover page of this manual.

CONSOLE CONTROLS 3

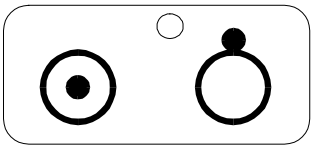
OPERATOR CONTROL PANEL



1. **Power ON and OFF buttons and POWER ON indicator**
2. **PREP and X-RAY exposure buttons and indicators**
3. **Image receptor buttons**
4. **AEC ON / OFF and field selector buttons**
5. **LCD display window**
6. **APR and technique selection and programming buttons**

POWER, PREP, AND X-RAY EXPOSURE CONTROLS

Power On, Power Off



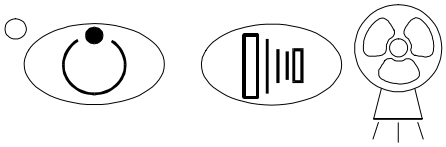
Press ⊙ to switch the X-ray generator on. The console will light up and a brief self - check will be performed.

The PREP and X-RAY LEDs should light briefly; this is an LED test and does NOT indicate the presence of X-RAYS.

Press **OK** and / or **RESET** to continue if any error messages are presented.

Press ○ to switch the generator off.

Prep, X-Ray Exposure and Exposure Indicator



Press and hold the prep button to spin the rotor. The prep indicator LED will light when ready to make an exposure.

While pressing the prep button, press and hold the exposure button to make an X-ray exposure.

The X-ray exposure indicator will light when an X-ray exposure is being taken.

Pressing the exposure button only will cycle the generator through prep and then exposure.

When the prep button is pressed, **PREPARATION** will be displayed in the LCD display window.

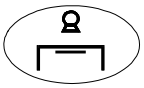
When the prep cycle is complete, **READY** will be displayed in the LCD display window.

During the X-ray exposure, **X - RAY EXPOSURE** will be displayed in the LCD display window.

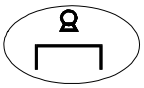
NOTE: ***IF YOUR GENERATOR USES "CAEC" AEC CHAMBER(S), REFER TO SEPARATE SUPPLEMENT AT FRONT OF THIS MANUAL IN CONJUNCTION WITH THIS MANUAL.***

IMAGE RECEPTOR CONTROLS

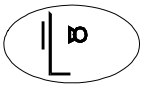
Table Bucky, Non - Bucky and Wall Bucky Image Receptor Selection



Press  to select the table Bucky image receptor.



Press  to select the table non - Bucky image receptor.



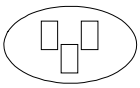
Press  to select the wall Bucky image receptor.

The mAs is automatically increased by a factor of approximately 3.4, relative to table non-Bucky selection, when the table or wall Bucky is selected due to the presence of a grid.

AEC CONTROLS

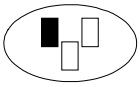
AEC ON / OFF Control and Field Selector Controls

- AEC is only available if the AEC option is installed and programmed.
- AEC operation is only available if the table or wall Bucky receptor is selected, and if AEC operation is enabled for the selected receptor.
- AEC operation may only be selected from within an anatomical technique screen. Refer to LCD DISPLAY WINDOW AND CONTROLS for further details.
- Left, middle, and right field selection is only available if 3 field V-pattern AEC chamber(s) are installed and programmed.



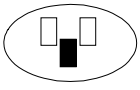
Press  to select or deselect AEC operation for the selected technique.

Press  to select the left AEC field.

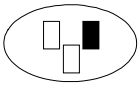


Press  to select the middle AEC field.

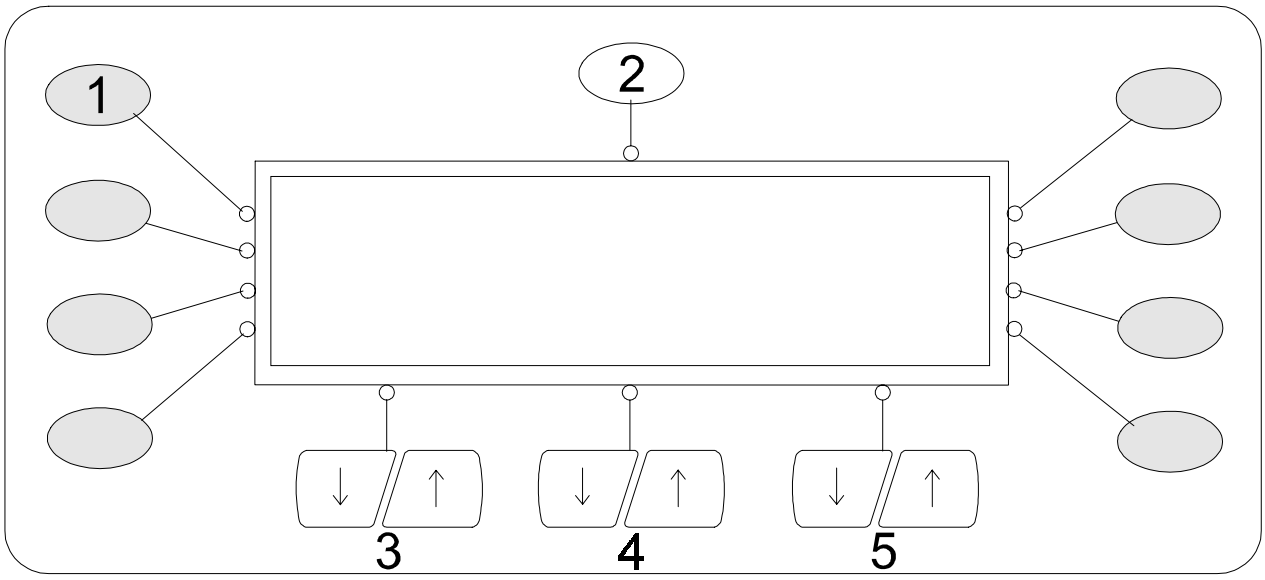
Press  to select the right AEC field.



All three AEC fields may not be deselected.



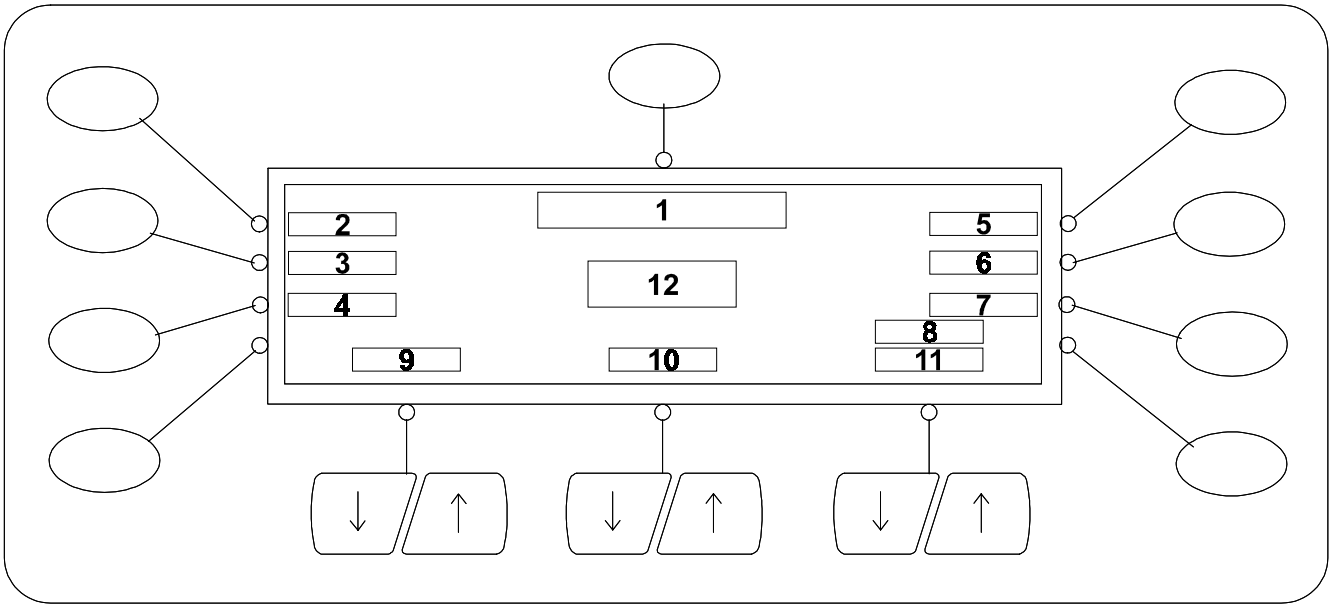
LCD DISPLAY WINDOW AND CONTROLS



1. These are the APR and technique selection and programming buttons, which perform different functions depending on the screen that is selected. This includes all of the buttons on the left and right side of the LCD display window (shaded gray in the above pictorial).
2. Menu button. In most cases, this selection returns the display to the previous screen or menu. Exceptions are described in the appropriate section.
3. CM selection buttons in normal operating mode.
4. kVp selection buttons.
5. mAs or density selection buttons in normal operating mode.

Button 3 performs additional functions in APR edit mode, refer to the section PROGRAMMING THE CONSOLE for further details.

The figure on the next page shows the fields on the LCD display where techniques and APR information is displayed. Each of these fields is described in the table following the figure.



FIELD	DISPLAY / FUNCTION
1	In normal operating mode, shows the anatomical section and anatomical view that has been selected. In APR edit mode, shows the anatomical section that has been selected. The anatomical view will alternate with the message ***EDIT MODE*** to indicate that the APR editor has been enabled.
2	Shows the film speed that has been pre-programmed for that technique. This may be altered in APR edit mode, as described in the section PROGRAMMING THE CONSOLE**.**
3	Selected S.I.D. Pressing the adjacent button will select 40″ or 72″ S.I.D. Changing the S.I.D. will automatically change the mAs as appropriate. The tube stand must be set to the corresponding S.I.D.
4	Shows the receptor that has been selected.
5	In normal operating mode, displays patient sizes AVERAGE, MUSC/OBESE, and PED/OSTEO. Pressing the adjacent button scrolls through the above sequence. Each step increase in size from ped/osteo to average to musc/obese automatically increases the mAs by approximately 30%. This field displays **RESET** during an error. Pressing the adjacent button will reset the error. In APR edit mode, displays messages as described in the section PROGRAMMING THE CONSOLE**.**

6	Selected focus. This may be changed by pressing the adjacent button. If small focus is selected, and the mAs is increased beyond a safe value for that focal spot, the focus will automatically change to large focus for the higher mAs settings. This will automatically switch back to small focus when the mAs is reduced to a safe value for that focal spot.
7	Selected mA for that technique. The mA may be changed by pressing the adjacent button. The mA will increase by one mA step each time the button is pressed. After maximum mA is reached the sequence will start over beginning with the minimum mA. mA values are automatically reduced as required to limit the output power per the generator or tube limits.
8	Shows the post mAs after an AEC exposure is completed.
9	In normal operating mode, displays the selected CM thickness. The mid value of the programmed CM range will initially be displayed. Pressing the adjacent ↑ or ↓ buttons will scroll through the available CM range for that anatomical view. The kVp and / or mAs is varied automatically as the CM is changed. In APR edit mode, displays CM related parameters as described in the section PROGRAMMING THE CONSOLE**.**
10	Selected kVp. Pressing the adjacent ↑ or ↓ buttons will scroll through the available kVp range. If the default kVp has been manually increased, ↑ will be displayed. If the default kVp has been manually decreased, ↓ will be displayed. mA values are automatically reduced as required to limit the output power per the generator or tube limits.
11	Displays mAs in non AEC mode. Pressing the adjacent ↑ or ↓ buttons will increase or decrease the mAs. If the default mAs has been manually increased, ↑ will be displayed. If the default mAs has been manually decreased, ↓ will be displayed. Refer to the note near the end of Chapter 4 (programming the console). This describes the relationship between mAs settings and AEC backup mAs (when in AEC mode). Displays density in AEC mode. Pressing the adjacent ↑ or ↓ buttons will increase or decrease the density. In APR edit mode, displays parameters as described in the section PROGRAMMING THE CONSOLE.
12	Message area. • Shows error and status messages when appropriate. • Shows  if AEC has been selected. The graphic indicates the selected fields via filled rectangles.

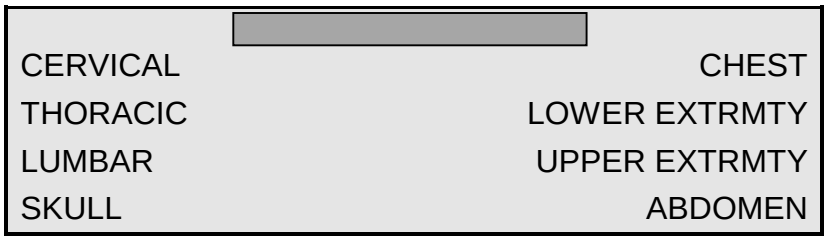
ANATOMICAL PROGRAMMING DISPLAY AND CONTROLS

When the generator is switched ON, the console performs a series of diagnostic tests. If an error is encountered, an error message will show in the LCD display. Refer to Chapter 5, ERROR CODES AND MESSAGES for details.

Press **OK** and / or **RESET**, if required, to proceed to the screen described below.

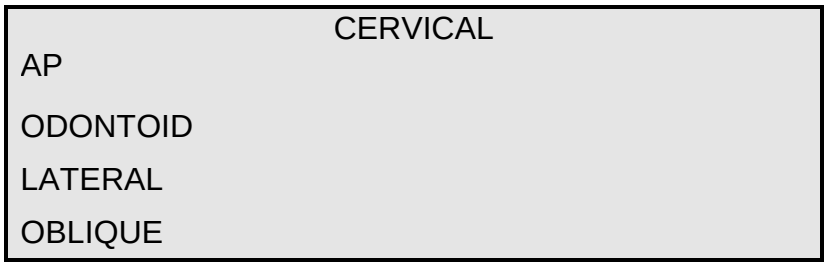
The main APR screen is shown below. ***Depending on generator model and configuration, the anatomical sections, views, and techniques displayed may be different from those shown.***

Press the button adjacent to the desired anatomical section to display the anatomical views within that section.

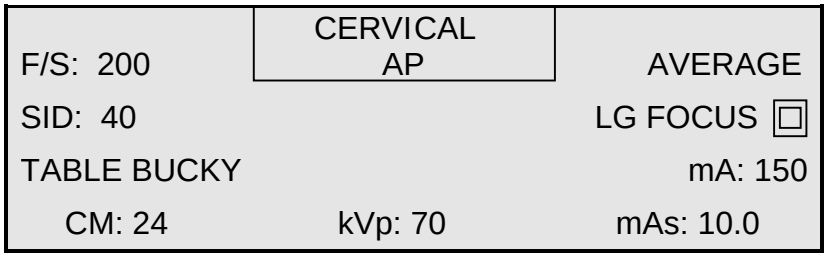


The selected anatomical views will display as shown below.

Press the button adjacent to the desired anatomical view to display the technique screen for that view.



The selected anatomical techniques will display as shown below.



MAKING AN X-RAY

The procedure below lists the recommended sequence of steps to make an X-ray exposure.

1. Switch ON the generator (page 14).
2. Select the desired technique (page 19). The technique screen will show preprogrammed settings. These settings may be temporarily changed as described below, or changes may be made to the techniques and saved for future use. Refer to Chapter 4, PROGRAMMING THE CONSOLE for the procedure to do this.

   An X-ray exposure may be made as per step 14 at this time if desired (if the default settings are accepable). Follow steps 3 to 11 if it is desired to temporarily change any of the displayed settings, then go to step 12 to make an X-ray exposure.

   Refer to the pictorial on page 17, and the table on pages 17, 18 in conjunction with the steps below.
3. Select the desired image receptor (page 15).
4. Select AEC if desired, then select the desired AEC fields (page 15).
5. Select the desired S.I.D. (item 3, page 17).
6. Select the desired patient size (AVERAGE, MUSC/OBESE, or PED/OSTEO). AVERAGE is the default selection (item 5, page 17).
7. Select the desired CM (item 9, page 18).
8. Select the desired mA (item 7, page 18).
9. Select the desired kVp (item 10, page 18).
10. Select the desired mAs for non-AEC operation, or the desired density for AEC operation (item 11, page 18).
11. Select the desired focus (item 6, page 18).
12. Press the PREP and / or X-RAY buttons when ready to make an X-ray exposure (page 14).

PROGRAMMING THE CONSOLE 4

The default techniques associated with the anatomical views in the LCD display window may be edited if desired. The date and time settings may also be changed by the operator. To perform the above functions(s), follow the steps in this Chapter.

ENTERING INTO PROGRAMMING MODE

1. Start with the generator switched OFF.
2. Press and hold the MENU button while pressing the POWER ON button on the operator console until the console beeps.
3. Release the MENU button and the POWER ON button.
4. The generator will go through its start up sequence. If an error message is presented when the start up sequence is completed, press **OK** and / or **RESET** to access the level 1 utility menu.
5. The following screen will be displayed.

Access is now provided to the following groups of functions.

APR SAVE OFF	• Enables/disables the ability to *make and then save* changes to APR techniques.
DATE & TIME	• Allows setting of the date and time.
EXIT	• Returns to normal operating mode (non setup/programming mode).
UTILITIES	• Accesses the level 2 utility functions. This function is not available to the operator.

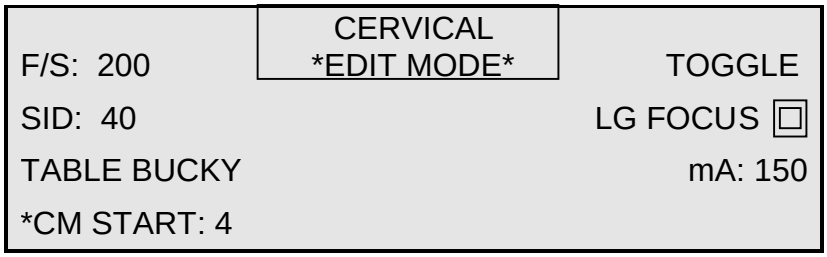
MAKING CHANGES TO APR TECHNIQUES

1. From the level 1 utility menu select **APR SAVE OFF.** This is the default when the generator is switched on in programming mode. The display will show **APR SAVE ON** if the APR save function has subsequently been changed to ON.

2. In the APR EDIT AND SAVE CONTROL screen, a prompt **APR SAVE OFF** will display. Press the adjacent button to toggle the selection of **APR SAVE OFF** or **APR SAVE ON**. When the desired APR edit mode is selected, press the menu button [**5**] to return to the level 1 utility menu.

3. With **APR SAVE ON**, press **EXIT** to return to the main APR screen.

4. Select the desired APR to edit. A typical screen is shown below.



NOTE: ***WHEN ENTERING AN APR EDIT SCREEN AS PER THE EXAMPLE ABOVE, "CM START" IS INITIALLY DISPLAYED. EXPOSURE VARIABLES PER STEP 5 CAN ONLY BE CHANGED WHEN "CM START" IS DISPLAYED.***

5. Select the exposure variable to change. The following order of editing the APR is recommended.
   (a) Select table Bucky, non Bucky, or wall Bucky operation.
   (b) Select AEC mode if desired. Select the desired AEC field(s) if AEC is selected.
   (c) Select the desired S.I.D.
   (d) Select large or small focus.
   (e) Select the desired mA.
   (f) Press **F/S** to set the desired film speed for the selected technique.

6. An asterisk appears beside CM START. Pressing the **TOGGLE** button will select CM STEP. Pressing the **TOGGLE** button again will select CM. Continuing to press **TOGGLE** will scroll the selection back to CM START, such that the sequence may be started over. In step 7, scroll through the CM START → CM STEP → CM selections as required to program these parameters.

   kVp and **mAs** are only displayed when CM is selected. Exposures are only allowed at this time when in APR edit mode.

CM START	The minimum CM for the selected technique (CM START range is 1 to 15). To program, refer to step 7.
CM STEP	The step size used to establish the CM vs kVp and mAs curve. The CM STEP range is 1 to 5. To program, refer to step 7.
CM	The steps on the CM vs kVp and mAs curve. To program, refer to step 7.

7. (a) Determine the minimum and maximum thickness in cm for the selected anatomical view. Thickness outside of this range cannot be selected later in normal operating mode, therefore these dimensions should be chosen carefully.

   (b) Determine the cm step size by the following formula:

$$\text{CM Step Size} = \frac{\text{Maximum thickness (cm)} - \text{Minimum thickness (cm)}}{8}$$

   The calculated step size must be rounded up to the nearest integer, i.e. 1.66 would round up to a step size of 2.

   (c) Select **CM START**, then enter the minimum thickness determined in step (a).

   (d) Select **CM STEP,** then enter the cm step size calculated in step (b), maximum step size = 5.

   (e) Select **CM**. Press the CM ↓ and ↑ buttons to confirm that the minimum and maximum thickness limits are acceptable. Repeat the above steps if necessary to optimize the minimum and maximum thickness limits. Set CM to minimum thickness before attempting to toggle back to CM START, else an error message **GO TO 1st CM!** will be presented.

   (f) Press CM ↓ to select the minimum thickness. Set the kVp and mAs as appropriate for the selected thickness.

   (g) Press CM ↑ to select the next thickness step. Set the kVp and mAs for that thickness as per 7 (f).

   Nine (9) thickness steps are available, with the step size as previously set. The desired kVp and mAs values may be set for each of those 9 thickness steps. In the normal operating mode, the thickness steps will be 1 cm, regardless of the step size set in APR edit mode. The console will interpolate between the step sizes set up in APR edit mode to determine the correct kVp and mAs for each 1 cm thickness step in normal operating mode.

7. (h) Repeat 7 (g) for the remaining CM steps.

8. When finished editing the APR, press the MENU button. Then press **SAVE**. The word **SAVING!** will briefly appear. The APR for that anatomical view will now be updated.

9. Repeat this procedure to edit other anatomical views.

10. Switch the generator OFF to exit the APR edit mode.

NOTE: ***IN AEC MODE, THE mAs SETTINGS (AS SET IN NON-AEC MODE) AFFECT AEC BACKUP mAs ONLY. BACKUP mAs IS CALCULATED FROM THE OPERATORS PROGRAMMED mAs VALUES. THE BACKUP mAs WILL BE 2 TIMES THE mAs VALUE; WITH AN UPPER LIMIT OF 600 mAs OR THE TUBE mAs LIMIT, WHICHEVER IS LESS.***

AEC BACKUP TIME IS DETERMINED BY DIVIDING BACKUP mAs BY mA, I.E. 100 BACKUP mAs ÷ 50 mA = 2 SEC.

THE AEC BACKUP TIME INFLUENCES THE SENSITIVITY OF THE AEC FAULT DETECTOR. IF THE AEC BACKUP mAs IS SET TOO LOW, A "LOW / NO AEC RAMP" FAULT MAY RESULT.

SETTING THE DATE AND TIME

1. From the level 1 utility menu select **DATE & TIME.**

2. Press ← or → to select the parameter to change (month, day, year, hour, or minute). The selection over the caret symbol **^** is the parameter that will be set in the next step.

3. Press **UP** or **DOWN** to set the selected parameter. Time is set in 24 hour mode.

4. Repeat steps 2 and 3 to set the remaining parameters.

5. Press the menu button to return to the main level 1 utility screen.

NOTE: ***1. THE TIME DOES NOT INCREMENT WHEN IN THE SETUP UTILITY.***

2. TIME AND DATE INFORMATION IS ONLY USED FOR CONSOLE INTERNAL CALCULATIONS.

ERROR CODES AND MESSAGES 5

The console will display status messages on the LCD display during normal and abnormal operation of the generator. This Chapter contains tables of those messages and suggests actions to be taken should any malfunctions occur.

START-UP MESSAGES

These messages are displayed at initial power-on only, and indicate the status at the time that the generator is switched on.

MESSAGE	DESCRIPTION
AEC MEMORY O.K. / ERR	Indicates that the AEC data checksums match. ERR indicates a requirement to contact your service representative.
APR MEMORY: O.K. / ERR	Indicates that the APR data checksums match. ERR indicates a requirement to contact your service representative.
CAL MEMORY: O.K. / ERR	O.K. indicates that the tube auto-calibration data checksums match. ERR indicates a requirement to contact your service representative.
HEAT SWITCH OPEN, TUBE MAY BE HOT	Indicates that the tube may be hot, wait for it to cool. If no success, contact your service representative.
LF DISABLED	Large focus has been disabled, only small focus is available.
LF UNCAL	The large focus is not calibrated, contact your service representative.
MEMORY TEST: O.K. / ERR	O.K. indicates that the EPROM data checksums match. ERR indicates a requirement to contact your service representative.
PROGRAM DATA: O.K. / ERR	O.K. indicates that the mAs step & error message checksums match. ERR indicates a requirement to contact your service representative.
RELEASE EXP. SW.	The exposure switch is closed while the generator is being powered-up. Release the exposure switch, if no success contact your service representative.
RT CLOCK: O.K. / ERR	O.K. indicates that the time is being incremented by the RT clock. ERR indicates that the date and time may need to be set, refer to Chapter 4. If no success, contact your service representative.
SOFTWARE REV	Displays the software revision in the console.
SF DISABLED	Small focus has been disabled, only large focus is available..
SF UNCAL	The small focus is not calibrated, contact your service representative.
STAMP ERROR: XX	Indicates that the date and time may need to be set, refer to Chapter 4. If no success, contact your service representative.
TUBE CALIBRATED	Both focal spots are calibrated.
TUBE DATA: O.K. / ERR	O.K. indicates that the tube insert data checksums match. ERR indicates a requirement to contact your service representative.
TUBE DISABLED. ENTER UTILITY TO ENABLE.	Both focal spots have been disabled in programming. Contact your service representative to enable.

STATUS MESSAGES

These messages indicate the status of the generator.

MESSAGE	DESCRIPTION
PREPARATION	Indicates that PREP has been requested.
READY	Indicates that the generator is ready to make an exposure.
X-RAY EXPOSURE	Indicates that an X-ray exposure is in progress.

LIMIT MESSAGES

These messages indicate that a request has been made that exceeds one or more limits.

MESSAGE	PROBLEM	ACTION
DENSITY LIMIT	The generator upper or lower density limit has been reached.	None required.
DUTY CYCLE LIMIT	Requested exposure not allowed until duty cycle limit expires.	Wait for time limit to expire.
FOCUS CHANGED!	Indicates that the focus has automatically changed while increasing or decreasing the mAs.	None required.
INVALID SETTING	Requested setting is invalid, ie attempting to deselect all AEC fields in AEC mode.	Correct the setting.
KVP LIMIT	The generator kVp limit has been reached.	None required.
LF MAS LIMIT	The generator large focus mAs limit has been reached.	Switch to small focus for mAs values < 1.0 mAS.
MA LIMIT	The generator mA limit has been reached.	None required.
MAS LIMIT	The generator mAs limit has been reached.	None required.
MAX MAS LIMIT	The generator power limit has been reached.	None required.
POWER KV LIMIT	Displayed if kV ↑ is pressed when the generator has reached its power limit.	None required.
POWER MAS LIMIT	Displayed if mAs ↑ is pressed when the generator has reached its power limit.	Reduce mAs.
SF MAS LIMIT	The generator small focus mAs limit has been reached.	Reduce mAs on small focus.
TUBE KW LIMIT	Displayed if requested parameter change will violate the tube data.	None required.
CALC. AEC RAMP LIMIT	Requested density correction will require a ramp voltage > 15.0V from AEC device.	Increase KVp and decrease density correction.
LOW RAMP LIMIT	Requested density correction will require a ramp voltage below noise threshold of AEC device (≅ 50mV)	Decrease KVp and increase density correction.

APR-EDIT MESSAGES

These messages indicate an invalid step or a request that exceeds one or more limits during APR edit mode.

MESSAGE	PROBLEM	ACTION
CHECK CM'S mAs & kV!	When in CM START, a value was found in one of the 9 CM steps that exceeds a tube or other limit.	Check that no exposure variable is exceeded for all kV / mAs settings at any CM steps.
CHECK CM'S kV!	When in CM START, a value was found in one of the 9 CM steps that exceeds the generator power limit.	Check that no exposure variable is exceeded for all kV / mAs settings at any CM steps.
GO TO CM START!	Displayed if attempting to change any exposure variable (film / screen, S.I.D., receptor, AEC, focus, etc) if in a CM setting other than CM START.	Toggle to CM START to enable changing these variables.
GO TO 1st CM!	Displayed if attempting to leave the CM screen while the CM setting is not at minimum CM.	Set CM to minimum value before continuing.
TUBE KW LIMIT DECREASE mAs	Displayed if increasing mA will exceed the tube kw limit.	Decrease mAs.
TUBE KW LIMIT DECREASE kV	Displayed if increasing kV will exceed the tube kw limit.	Decrease kV.

ERROR MESSAGES

These messages indicate that an error has occurred.

MESSAGE	PROBLEM	ACTION
40 INCH ITLK	Indicates that the 40 ″ S.I.D. has been selected, but the tube stand is not in the 40 ″ S.I.D. position.	Check S.I.D. on tube stand.
72 INCH ITLK	Indicates that the 72 ″ S.I.D. has been selected, but the tube stand is not in the 72 ″ S.I.D. position.	Check S.I.D. on tube stand.
AEC INTERLOCK	Indicates that no AEC device is connected.	Contact your service representative.
BACKUP MAS	The AEC backup mAs timer, and not the AEC circuits, terminated the AEC exposure.	1. Check the BUmAs setting, as shown on page 24. 2. Contact your service representative.
BACKUP TIMER	The generator backup timer terminated the exposure at the limit of 6000 ms for non AEC exposures, or the BUmAS limit for AEC exposures.	Increase the mA for non AEC exposures, or increase the BUmAs for AEC exposures.
DEVICE INTERRUPT	Indicates that the selected Bucky ready signal is no longer present.	1. Wait for Bucky ready. 2. Contact your service representative.
FAULTY EXP. SW.	Indicates that the exposure switch is closed during power-up. This message is displayed if the switch is not opened immediately after the RELEASE EXP. SW. message is displayed.	1. Release exposure switch. 2. Contact your service representative.
FILAMENT FAULT	Indicates that a filament fault has been detected.	Contact your service representative.
FOCUS DISABLED	Indicates that the requested focal spot has been deprogrammed.	Select the other focal spot.

ERROR MESSAGES (Cont)

HEAT SW. ITR.	Indicates that the thermal switch has opened during an exposure.	Allow the X-ray tube to cool.
kV HIGH	Indicates that a kV high fault has been detected.	Contact your service representative.
kV LOW	Indicates that a kV low fault has been detected.	Contact your service representative.
LOW / NO AEC RAMP	A low (or no) AEC ramp has been detected from the AEC chamber during the first 50 ms of AEC exposure.	1. Check settings (techniques, mA mAs, receptor selection, etc). 2. Contact your service representative.
mA HIGH	Indicates that a mA high fault has been detected.	Contact your service representative.
mA LOW	Indicates that a mA low fault has been detected.	Contact your service representative.
MANUAL INTERRUPT	The X-ray exposure switch was released before the exposure was finished.	Hold the exposure switch until the exposure is finished.
POWER UP FAILURE, CHECK LINE VOLT.	Indicates that the generator did not power up within 30 seconds of the console being switched on.	Contact your service representative.
P/S FAULT	Indicates that the generator is not ready to make an exposure.	Contact your service representative.
P/S NOT READY	Indicates that the main line contactor in the generator is not commanded to close.	Contact your service representative.
ROTOR FAILURE, TURN UNIT OFF	Indicates that the rotor is running at any time other than during prep or during an exposure.	Contact your service representative.

ERROR MESSAGES (Cont)

ROTOR FAULT	Indicates that the low speed starter board has not sensed adequate stator current.	Contact your service representative.
TUBE DISABLED	Both focal spots are disabled.	Contact your service representative.
TUBE FAULT	Indicates a fault has been detected in the kV or mA output, or in the inverter circuits.	Contact your service representative.
UNCOMMANDED KV	Indicates that kV feedback has been detected when no kV has been requested.	Switch generator OFF. Prevent further use of generator until problem is fixed. Contact your service representative.

GENERATOR EXPOSURE TABLES 6

Table 1 following shows nominal exposure times resulting from preselected mAs and mA values. This table also shows the range and interrelation of these loading factors. For example, if 20 mAs is selected at 200 mA, it can be seen that the exposure time will be approximately 100 ms. This is determined by reading down the 200 mA column to the 20 mAs row; the nominal exposure time 100 ms is shown at the intersection of the 200 mA column and the 20 mAs row.

An extra copy of this table is provided on pages 37 to 41 that may be photocopied as required, or removed from this manual and placed in a suitable location as per local requirements.

GENERATOR TECHNIQUE SELECTION
(2 Point Selection: Exposure time vs mAs & mA)

mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
0.1	4																			
0.2	8	4																		
0.3	12	6	4																	
0.4	16	8	5.3	4																
0.5	20	10	6.7	5																
0.6	24	12	8	6																
0.7	28	14	9.3	7																
0.8	32	16	10.7	8																
0.9	36	18	12	9																
1.0	40	20	13.3	10																
1.1	44	22	14.7	11																
1.2	48	24	16	12																
1.4	56	28	18.7	14	11.2															
1.6	64	32	21.3	16	12.8	10.7														
1.8	72	36	24	18	14.4	12	10.3													
2.0	80	40	26.7	20	16	13.3	11.4	10												
2.1 *	84	42	28	21	16.8	14	12	10.5												
2.2 **	88	44	29.3	22	17.6	14.7	12.6	11												
2.3 *	92	46	31	23	18.4	15.3	13.1	11.5	10.2											
2.5	100	50	33	25	20	16.7	14.3	12.5	11.1	10										
2.6 **	104	52	35	26	20.8	17.3	14.9	13	11.6	10.4										
2.8	112	56	37	28	22.4	18.7	16	14	12.4	11.2	10.2									

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
3.0 *	120	60	40	30	24	20	17.1	15	13.3	12	10.9	10								
3.2 **	128	64	43	32	25.6	21.3	18.3	16	14.2	12.8	11.6	10.7								
3.4 *	136	68	45	34	27.2	22.7	19.4	17	15.1	13.6	12.4	11.3	10.5							
3.6 **	144	72	48	36	28.8	24	20.6	18	16	14.4	13.1	12	11.1	10.3						
3.8	152	76	51	38	30	25.3	21.7	19	16.9	15.2	13.8	12.7	11.7	10.9	10.1					
4.0	160	80	53	40	32	26.7	22.9	20	17.8	16	14.5	13.3	12.3	11.4	10.7	10				
4.2 *	168	84	56	42	34	28	24	21	18.7	16.8	15.3	14	12.9	12	11.2	10.5				
4.5	180	90	60	45	36	30	25.7	22.5	20	18	16.4	15	13.8	12.9	12	11.3	10.6	10		
4.8 *	192	96	64	48	38	32	27.4	24	21.3	19.2	17.5	16	14.8	13.7	12.8	12	11.3	10.7	10.1	
5.0	200	100	67	50	40	33	28.6	25	22.2	20	18.2	16.7	15.4	14.3	13.3	12.5	11.8	11.1	10.5	10
5.3	212	106	71	53	42	35	30	26.5	23.6	21.2	19.3	17.7	16.3	15.1	14.1	13.3	12.5	11.8	11.2	10.6
5.6	224	112	75	56	45	37	32	28	24.9	22.4	20.4	18.7	17.2	16	14.9	14	13.2	12.4	11.8	11.2
6.0	240	120	80	60	48	40	34	30	26.7	24	21.8	20	18.5	17.1	16	15	14.1	13.3	12.6	12
6.3	252	126	84	63	50	42	36	32	28	25.2	22.9	21	19.4	18	16.8	15.8	14.8	14.	13.3	12.6
6.7	268	134	89	67	54	45	38	34	30	26.8	24.4	22.3	20.6	19.1	17.9	16.8	15.8	14.9	14.1	13.4
7.1	284	142	97	71	57	47	41	36	32	28.4	25.8	23.7	21.8	20.3	18.9	17.8	16.7	15.8	14.9	14.2
7.5	300	150	100	75	60	50	43	38	33	30	27.3	25	23.1	21.4	20	18.2	17.6	16.7	15.8	15
8.0	320	160	107	80	64	53	46	40	36	32	29.1	26.7	24.6	22.9	21.3	20	18.8	17.8	16.8	16
8.5	340	170	113	85	68	57	49	43	38	34	31	28.3	26.2	24.3	22.7	21.3	20	18.9	17.9	17
9.0	360	180	120	90	72	60	51	45	40	36	33	30	27.7	25.7	24	22.5	21.2	20	18.9	18
9.5	380	190	127	95	76	63	54	48	42	38	35	32	29.2	27.1	25.3	23.8	22.4	21.1	20	19
10	400	200	133	100	80	67	57	50	44	40	36	33	31	2.6	26.7	25	23.5	22.2	21.1	20
10.5	420	210	140	105	84	70	60	53	47	42	38	35	32	30	28	26.3	24.7	23.3	22.1	21
11	440	220	147	110	88	73	63	55	49	44	40	37	34	31	29.3	27.5	25.9	24.4	23.2	22

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
12.5	500	250	167	125	100	83	71	63	56	50	45	42	39	36	33	31	29.4	27.8	26.3	25
14	560	280	187	140	112	93	80	70	62	56	51	47	43	40	37	35	33	31	29.5	28
15 *	600	300	200	150	120	100	86	75	67	60	55	50	46	43	40	38	35	33	32	30
16	640	320	213	160	128	107	91	80	71	64	58	53	49	46	43	40	38	36	34	32
17 *	680	340	227	170	136	113	97	85	76	68	62	57	52	49	45	43	40	38	36	34
18	720	360	240	180	144	120	103	90	80	72	65	60	55	51	48	45	42	40	38	36
19 *	760	380	253	190	152	127	109	95	84	76	69	63	59	54	51	48	45	42	40	38
20	800	400	267	200	160	133	114	100	89	80	73	67	62	57	53	50	47	44	42	40
21 *	840	420	280	210	168	140	120	105	93	84	76	70	65	60	56	53	49	47	44	42
22	880	440	293	220	176	147	126	110	98	88	80	73	68	63	59	55	52	49	46	44
24	960	480	320	240	192	160	137	120	107	96	87	80	74	69	64	60	56	53	51	48
25 *	1000	500	333	250	200	167	143	125	111	100	91	83	77	71	67	63	59	56	53	50
26	1040	520	347	260	208	173	149	130	116	104	95	87	80	74	69	65	61	58	55	52
28	1120	560	373	280	224	187	160	140	124	112	102	93	86	80	75	70	66	62	59	56
32	1280	640	427	320	256	213	183	160	142	128	116	107	99	91	85	80	75	71	67	64
34	1360	680	453	340	272	227	194	170	151	136	124	113	105	97	91	85	80	76	72	68
36	1440	720	480	360	288	240	206	180	160	144	131	120	111	103	96	90	85	80	76	72
38	1520	760	507	380	304	253	217	190	169	152	138	127	117	109	101	95	89	84	80	76
40	1600	800	533	400	320	267	229	200	178	160	145	133	123	114	107	100	94	89	84	80
42	1680	840	560	420	336	280	240	210	187	168	153	140	129	120	112	105	99	93	88	84
45	1800	900	600	450	360	300	257	225	200	180	164	150	138	129	120	113	106	100	95	90
48	1920	960	640	480	384	320	274	240	213	192	175	160	148	137	128	120	113	107	101	96
50	2000	1000	667	500	400	333	286	250	222	200	182	167	154	143	133	125	118	111	105	100
53	2120	1060	707	530	424	353	303	265	236	212	193	177	163	151	141	133	125	118	112	106
56	2240	1120	747	560	448	373	320	280	249	224	204	187	172	160	149	140	132	124	118	112

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
60	2400	1200	800	600	480	400	343	300	267	240	218	200	185	171	160	150	141	133	126	120
63	2520	1260	840	630	504	420	360	315	280	252	229	210	194	180	168	158	148	140	133	126
67	2680	1340	893	670	536	447	383	335	298	268	244	223	206	191	179	168	158	149	141	134
71	2840	1420	947	710	568	473	406	355	316	284	258	237	218	203	189	178	167	158	149	142
75	3000	1500	1000	750	600	500	429	375	333	300	273	250	231	214	200	188	176	167	158	150
80	3200	1600	1067	800	640	533	457	400	356	320	291	267	246	229	213	200	188	178	168	160
85	3400	1700	1133	850	680	567	486	425	378	340	309	283	262	243	227	213	200	189	179	170
90	3600	1800	1200	900	720	600	514	450	400	360	327	300	277	257	240	225	212	200	189	180
95	3800	1900	1267	950	760	633	543	475	422	380	345	317	292	271	253	238	224	211	200	190
100	4000	2000	1333	1000	800	667	571	500	444	400	364	333	308	286	267	250	235	222	211	200
105	4200	2100	1400	1050	840	700	600	525	467	420	382	350	323	300	280	263	247	233	221	210
110	4400	2200	1467	1100	880	733	629	550	489	440	400	367	338	314	293	275	259	244	232	220
125	5000	2500	1667	1250	1000	833	714	625	556	500	455	417	385	357	333	313	294	278	263	250
130 **	5200	2600	1733	1300	1040	867	743	650	578	520	473	433	400	371	347	325	306	289	274	260
140	5600	2800	1867	1400	1120	933	800	700	622	560	509	467	431	400	373	350	329	311	295	280
150	6000	3000	2000	1500	1200	1000	857	750	667	600	545	500	462	429	400	375	353	333	316	300
160		3200	2133	1600	1280	1067	914	800	711	640	582	533	492	457	427	400	376	356	337	320
170		3400	2267	1700	1360	1133	971	850	756	680	618	567	523	486	453	425	400	378	358	340
180		3600	2400	1800	1440	1200	1029	900	800	720	655	600	554	514	480	450	424	400	379	360
190 *		3800	2533	1900	1520	1267	1086	950	844	760	691	633	585	543	507	475	447	422	400	380
200		4000	2667	2000	1600	1333	1143	1000	889	800	727	667	615	571	533	500	471	444	421	400
210 *		4200	2800	2100	1680	1400	1200	1050	933	840	764	700	646	600	560	525	494	467	442	420
220		4400	2933	2200	1760	1467	1257	1100	978	880	800	733	677	629	587	550	518	489	463	440
240 *		4800	3200	2400	1920	1600	1371	1200	1067	960	873	800	738	686	640	600	565	533	505	486
250		5000	3333	2500	2000	1667	1429	1250	1111	1000	909	833	769	714	667	625	588	556	526	500

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
260		5200	3467	2600	2080	1733	1486	1300	1156	1040	945	867	800	743	693	650	612	578	547	520
280		5600	3733	2800	2240	1867	1600	1400	1244	1120	1018	933	862	800	747	700	659	622	589	560
300		6000	4000	3000	2400	2000	1714	1500	1333	1200	1091	1000	923	857	800	750	706	667	632	600
320			4267	3200	2560	2133	1829	1600	1422	1280	1164	1067	985	914	853	800	753	711	674	640
340			4533	3400	2720	2267	1943	1700	1511	1360	1236	1133	1046	971	907	850	800	756	716	680
360			4800	3600	2880	2400	2057	1800	1600	1440	1309	1200	1108	1029	960	900	847	800	758	720
380			5067	3800	3040	2533	2171	1900	1689	1520	1382	1267	1169	1086	1013	950	894	844	800	760
400			5333	4000	3200	2667	2286	2000	1778	1600	1455	1333	1231	1143	1067	1000	941	889	842	800
420			5600	4200	3360	2800	2400	2100	1867	1680	1527	1400	1292	1200	1120	1050	988	933	884	840
440 **			5867	4400	3520	2933	2514	2200	1956	1760	1600	1467	1354	1257	1173	1100	1035	978	926	880
460 **				4600	3680	3067	2629	2300	2044	1840	1673	1533	1415	1314	1227	1150	1082	1022	968	920
480 **				4800	3840	3200	2743	2400	2133	1920	1745	1600	1477	1371	1280	1200	1129	1067	1011	960
500 **				5000	4000	3333	2857	2500	2222	2000	1818	1667	1538	1429	1333	1250	1176	1111	1053	1000
520 **				5200	4160	3467	2971	2600	2311	2080	1891	1733	1600	1486	1387	1300	1224	1156	1095	1040
540 **				5400	4320	3600	3086	2700	2400	2160	1964	1800	1662	1543	1440	1350	1271	1200	1137	1080
560 **				5600	4480	3733	3200	2800	2489	2240	2036	1867	1723	1600	1493	1400	1318	1244	1179	1120
580 **				5800	4640	3867	3314	2900	2578	2320	2109	1933	1785	1657	1547	1450	1365	1289	1221	1160
600 **				6000	4800	4000	3429	3000	2667	2400	2182	2000	1846	1714	1600	1500	1412	1333	1263	1200

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

GENERATOR TECHNIQUE SELECTION
(2 Point Selection: Exposure time vs mAs & mA)

mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
0.1	4																			
0.2	8	4																		
0.3	12	6	4																	
0.4	16	8	5.3	4																
0.5	20	10	6.7	5																
0.6	24	12	8	6																
0.7	28	14	9.3	7																
0.8	32	16	10.7	8																
0.9	36	18	12	9																
1.0	40	20	13.3	10																
1.1	44	22	14.7	11																
1.2	48	24	16	12																
1.4	56	28	18.7	14	11.2															
1.6	64	32	21.3	16	12.8	10.7														
1.8	72	36	24	18	14.4	12	10.3													
2.0	80	40	26.7	20	16	13.3	11.4	10												
2.1 *	84	42	28	21	16.8	14	12	10.5												
2.2 **	88	44	29.3	22	17.6	14.7	12.6	11												
2.3 *	92	46	31	23	18.4	15.3	13.1	11.5	10.2											
2.5	100	50	33	25	20	16.7	14.3	12.5	11.1	10										
2.6 **	104	52	35	26	20.8	17.3	14.9	13	11.6	10.4										
2.8	112	56	37	28	22.4	18.7	16	14	12.4	11.2	10.2									

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
3.0 *	120	60	40	30	24	20	17.1	15	13.3	12	10.9	10								
3.2 **	128	64	43	32	25.6	21.3	18.3	16	14.2	12.8	11.6	10.7								
3.4 *	136	68	45	34	27.2	22.7	19.4	17	15.1	13.6	12.4	11.3	10.5							
3.6 **	144	72	48	36	28.8	24	20.6	18	16	14.4	13.1	12	11.1	10.3						
3.8	152	76	51	38	30	25.3	21.7	19	16.9	15.2	13.8	12.7	11.7	10.9	10.1					
4.0	160	80	53	40	32	26.7	22.9	20	17.8	16	14.5	13.3	12.3	11.4	10.7	10				
4.2 *	168	84	56	42	34	28	24	21	18.7	16.8	15.3	14	12.9	12	11.2	10.5				
4.5	180	90	60	45	36	30	25.7	22.5	20	18	16.4	15	13.8	12.9	12	11.3	10.6	10		
4.8 *	192	96	64	48	38	32	27.4	24	21.3	19.2	17.5	16	14.8	13.7	12.8	12	11.3	10.7	10.1	
5.0	200	100	67	50	40	33	28.6	25	22.2	20	18.2	16.7	15.4	14.3	13.3	12.5	11.8	11.1	10.5	10
5.3	212	106	71	53	42	35	30	26.5	23.6	21.2	19.3	17.7	16.3	15.1	14.1	13.3	12.5	11.8	11.2	10.6
5.6	224	112	75	56	45	37	32	28	24.9	22.4	20.4	18.7	17.2	16	14.9	14	13.2	12.4	11.8	11.2
6.0	240	120	80	60	48	40	34	30	26.7	24	21.8	20	18.5	17.1	16	15	14.1	13.3	12.6	12
6.3	252	126	84	63	50	42	36	32	28	25.2	22.9	21	19.4	18	16.8	15.8	14.8	14.	13.3	12.6
6.7	268	134	89	67	54	45	38	34	30	26.8	24.4	22.3	20.6	19.1	17.9	16.8	15.8	14.9	14.1	13.4
7.1	284	142	97	71	57	47	41	36	32	28.4	25.8	23.7	21.8	20.3	18.9	17.8	16.7	15.8	14.9	14.2
7.5	300	150	100	75	60	50	43	38	33	30	27.3	25	23.1	21.4	20	18.2	17.6	16.7	15.8	15
8.0	320	160	107	80	64	53	46	40	36	32	29.1	26.7	24.6	22.9	21.3	20	18.8	17.8	16.8	16
8.5	340	170	113	85	68	57	49	43	38	34	31	28.3	26.2	24.3	22.7	21.3	20	18.9	17.9	17
9.0	360	180	120	90	72	60	51	45	40	36	33	30	27.7	25.7	24	22.5	21.2	20	18.9	18
9.5	380	190	127	95	76	63	54	48	42	38	35	32	29.2	27.1	25.3	23.8	22.4	21.1	20	19
10	400	200	133	100	80	67	57	50	44	40	36	33	31	2.6	26.7	25	23.5	22.2	21.1	20
10.5	420	210	140	105	84	70	60	53	47	42	38	35	32	30	28	26.3	24.7	23.3	22.1	21
11	440	220	147	110	88	73	63	55	49	44	40	37	34	31	29.3	27.5	25.9	24.4	23.2	22

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
12.5	500	250	167	125	100	83	71	63	56	50	45	42	39	36	33	31	29.4	27.8	26.3	25
14	560	280	187	140	112	93	80	70	62	56	51	47	43	40	37	35	33	31	29.5	28
15 *	600	300	200	150	120	100	86	75	67	60	55	50	46	43	40	38	35	33	32	30
16	640	320	213	160	128	107	91	80	71	64	58	53	49	46	43	40	38	36	34	32
17 *	680	340	227	170	136	113	97	85	76	68	62	57	52	49	45	43	40	38	36	34
18	720	360	240	180	144	120	103	90	80	72	65	60	55	51	48	45	42	40	38	36
19 *	760	380	253	190	152	127	109	95	84	76	69	63	59	54	51	48	45	42	40	38
20	800	400	267	200	160	133	114	100	89	80	73	67	62	57	53	50	47	44	42	40
21 *	840	420	280	210	168	140	120	105	93	84	76	70	65	60	56	53	49	47	44	42
22	880	440	293	220	176	147	126	110	98	88	80	73	68	63	59	55	52	49	46	44
24	960	480	320	240	192	160	137	120	107	96	87	80	74	69	64	60	56	53	51	48
25 *	1000	500	333	250	200	167	143	125	111	100	91	83	77	71	67	63	59	56	53	50
26	1040	520	347	260	208	173	149	130	116	104	95	87	80	74	69	65	61	58	55	52
28	1120	560	373	280	224	187	160	140	124	112	102	93	86	80	75	70	66	62	59	56
32	1280	640	427	320	256	213	183	160	142	128	116	107	99	91	85	80	75	71	67	64
34	1360	680	453	340	272	227	194	170	151	136	124	113	105	97	91	85	80	76	72	68
36	1440	720	480	360	288	240	206	180	160	144	131	120	111	103	96	90	85	80	76	72
38	1520	760	507	380	304	253	217	190	169	152	138	127	117	109	101	95	89	84	80	76
40	1600	800	533	400	320	267	229	200	178	160	145	133	123	114	107	100	94	89	84	80
42	1680	840	560	420	336	280	240	210	187	168	153	140	129	120	112	105	99	93	88	84
45	1800	900	600	450	360	300	257	225	200	180	164	150	138	129	120	113	106	100	95	90
48	1920	960	640	480	384	320	274	240	213	192	175	160	148	137	128	120	113	107	101	96
50	2000	1000	667	500	400	333	286	250	222	200	182	167	154	143	133	125	118	111	105	100
53	2120	1060	707	530	424	353	303	265	236	212	193	177	163	151	141	133	125	118	112	106
56	2240	1120	747	560	448	373	320	280	249	224	204	187	172	160	149	140	132	124	118	112

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
60	2400	1200	800	600	480	400	343	300	267	240	218	200	185	171	160	150	141	133	126	120
63	2520	1260	840	630	504	420	360	315	280	252	229	210	194	180	168	158	148	140	133	126
67	2680	1340	893	670	536	447	383	335	298	268	244	223	206	191	179	168	158	149	141	134
71	2840	1420	947	710	568	473	406	355	316	284	258	237	218	203	189	178	167	158	149	142
75	3000	1500	1000	750	600	500	429	375	333	300	273	250	231	214	200	188	176	167	158	150
80	3200	1600	1067	800	640	533	457	400	356	320	291	267	246	229	213	200	188	178	168	160
85	3400	1700	1133	850	680	567	486	425	378	340	309	283	262	243	227	213	200	189	179	170
90	3600	1800	1200	900	720	600	514	450	400	360	327	300	277	257	240	225	212	200	189	180
95	3800	1900	1267	950	760	633	543	475	422	380	345	317	292	271	253	238	224	211	200	190
100	4000	2000	1333	1000	800	667	571	500	444	400	364	333	308	286	267	250	235	222	211	200
105	4200	2100	1400	1050	840	700	600	525	467	420	382	350	323	300	280	263	247	233	221	210
110	4400	2200	1467	1100	880	733	629	550	489	440	400	367	338	314	293	275	259	244	232	220
125	5000	2500	1667	1250	1000	833	714	625	556	500	455	417	385	357	333	313	294	278	263	250
130 **	5200	2600	1733	1300	1040	867	743	650	578	520	473	433	400	371	347	325	306	289	274	260
140	5600	2800	1867	1400	1120	933	800	700	622	560	509	467	431	400	373	350	329	311	295	280
150	6000	3000	2000	1500	1200	1000	857	750	667	600	545	500	462	429	400	375	353	333	316	300
160		3200	2133	1600	1280	1067	914	800	711	640	582	533	492	457	427	400	376	356	337	320
170		3400	2267	1700	1360	1133	971	850	756	680	618	567	523	486	453	425	400	378	358	340
180		3600	2400	1800	1440	1200	1029	900	800	720	655	600	554	514	480	450	424	400	379	360
190 *		3800	2533	1900	1520	1267	1086	950	844	760	691	633	585	543	507	475	447	422	400	380
200		4000	2667	2000	1600	1333	1143	1000	889	800	727	667	615	571	533	500	471	444	421	400
210 *		4200	2800	2100	1680	1400	1200	1050	933	840	764	700	646	600	560	525	494	467	442	420
220		4400	2933	2200	1760	1467	1257	1100	978	880	800	733	677	629	587	550	518	489	463	440
240 *		4800	3200	2400	1920	1600	1371	1200	1067	960	873	800	738	686	640	600	565	533	505	486
250		5000	3333	2500	2000	1667	1429	1250	1111	1000	909	833	769	714	667	625	588	556	526	500

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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mAs	mA Selected																			
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
260		5200	3467	2600	2080	1733	1486	1300	1156	1040	945	867	800	743	693	650	612	578	547	520
280		5600	3733	2800	2240	1867	1600	1400	1244	1120	1018	933	862	800	747	700	659	622	589	560
300		6000	4000	3000	2400	2000	1714	1500	1333	1200	1091	1000	923	857	800	750	706	667	632	600
320			4267	3200	2560	2133	1829	1600	1422	1280	1164	1067	985	914	853	800	753	711	674	640
340			4533	3400	2720	2267	1943	1700	1511	1360	1236	1133	1046	971	907	850	800	756	716	680
360			4800	3600	2880	2400	2057	1800	1600	1440	1309	1200	1108	1029	960	900	847	800	758	720
380			5067	3800	3040	2533	2171	1900	1689	1520	1382	1267	1169	1086	1013	950	894	844	800	760
400			5333	4000	3200	2667	2286	2000	1778	1600	1455	1333	1231	1143	1067	1000	941	889	842	800
420			5600	4200	3360	2800	2400	2100	1867	1680	1527	1400	1292	1200	1120	1050	988	933	884	840
440 **			5867	4400	3520	2933	2514	2200	1956	1760	1600	1467	1354	1257	1173	1100	1035	978	926	880
460 **				4600	3680	3067	2629	2300	2044	1840	1673	1533	1415	1314	1227	1150	1082	1022	968	920
480 **				4800	3840	3200	2743	2400	2133	1920	1745	1600	1477	1371	1280	1200	1129	1067	1011	960
500 **				5000	4000	3333	2857	2500	2222	2000	1818	1667	1538	1429	1333	1250	1176	1111	1053	1000
520 **				5200	4160	3467	2971	2600	2311	2080	1891	1733	1600	1486	1387	1300	1224	1156	1095	1040
540 **				5400	4320	3600	3086	2700	2400	2160	1964	1800	1662	1543	1440	1350	1271	1200	1137	1080
560 **				5600	4480	3733	3200	2800	2489	2240	2036	1867	1723	1600	1493	1400	1318	1244	1179	1120
580 **				5800	4640	3867	3314	2900	2578	2320	2109	1933	1785	1657	1547	1450	1365	1289	1221	1160
600 **				6000	4800	4000	3429	3000	2667	2400	2182	2000	1846	1714	1600	1500	1412	1333	1263	1200

Table 1: Nominal exposure time (ms) vs mAs and mA selected.

NOTE: mA, mAs, and time (ms) values with no asterisk in mAs column in table 1 apply to 30, 32.5, 37.5, and 50 kW generators. Values in mAs column with one asterisk (*) apply to 30, 32.5, and 37.5 kW generators only. Values in mAs column with two asterisks (**) apply to 50 kW generators only. mA limits are 300 mA for 30 kW generators, 325 mA for 32.5 kW generators, 375 mA for 37.5 kW generators, and 500 mA for 50 kW generators.

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MAINTENANCE SCHEDULE 7

This section is organized into two parts. The first part of this section details tests by which the operator can verify that the AEC circuits are functioning. These tests should be done monthly as a minimum, or more frequently if required by local regulations.

CAUTION: ***THE AEC VERIFICATION PROCEDURE REQUIRES THE PRODUCTION OF X-RAYS. OBSERVE CORRECT OPERATING PROCEDURES, AND TAKE APPROPRIATE PRECAUTIONS AGAINST X-RADIATION.***

The second part of this section is the recommended maintenance schedule for your generator.

WARNING: ***REFER ALL SERVICING TO APPROPRIATE SERVICE PERSONNEL WHO ARE TRAINED TO SERVICE THIS EQUIPMENT AND WHO ARE FAMILIAR WITH THE POTENTIAL HAZARDS ASSOCIATED WITH THIS EQUIPMENT.***

NOTE: ***MAINTENANCE SCHEDULE FREQUENCY MAY BE DETERMINED BY CERTAIN REGULATORY REQUIREMENTS OF THE COUNTRY OR STATE IN WHICH THE INSTALLATION IS LOCATED. ALWAYS CHECK THE LOCAL CODES AND REGULATIONS WHEN DETERMINING A MAINTENANCE SCHEDULE.***

AEC FUNCTIONAL CHECK

The following procedure may be used to verify that the AEC circuits are functioning on generators equipped with AEC (automatic exposure control).

1. Switch the generator ON, and select an appropriate radiographic image receptor.
2. Align the X-ray tube and the selected image receptor such that the central ray is directly over the center field of the AEC pickup device. Set the focal spot to film plane distance to 40 ″.
3. Select AEC mode of operation. Select center field, large focus.

MINIMUM EXPOSURE TIME:

4. With no object in the radiation field, adjust the collimator or beam limiting device to project a 10 ″ X 10 ″ (24 cm X 24 cm) field at the image receptor.
5. Select 80 kVp and 100 mA.
6. Make an exposure and verify that the POST mAs reading is ≤ 1.67 mAs.

MAXIMUM EXPOSURE TIME:

7. With the collimator set as in step 4, place 0.2 ″ (5 mm) of copper or equivalent absorber in the X-ray field. The absorber must fully block the beam.
8. Select 70 kVp and 50 mA.
9. Make an exposure and verify that the error message **BACKUP TIMER** is indicated in the LCD display window after the exposure has terminated. This confirms that the exposure has continued until it was terminated by the AEC backup timer.

MAINTENANCE ACTIVITIES IN THE TABLE BELOW ARE TO BE PERFORMED BY AUTHORIZED SERVICE PERSONNEL ONLY. HOWEVER THE ONUS IS ON YOU, THE OWNER OR OPERATOR OF THE EQUIPMENT, TO SCHEDULE THE SUGGESTED MAINTENANCE ACTIVITY WHEN REQUIRED.

Maintenance Frequency	Description of Preventative Maintenance
Every 6 Months AND whenever a related certifiable X-ray component is replaced:	1. Clean and re-grease all HV connections using vapor proof compound. 2. Check that all HV connections are tight. 3. Clean the control console and main cabinet as needed. **REFER TO NEXT PAGE, CLEANING, BEFORE PROCEEDING.** 4. Perform the X-ray tube auto calibration routine. 5. Verify the calibration of the generator. 6. Perform any additional tests required by laws governing this installation.
Every 12 months:	1. Examine the following for any visible damage and replace any damaged components: • The exterior of the control console, including the membrane switch assembly. • The cables between the control console and the generator main cabinet. • The cable(s) between the control console and the AEC chambers (if the AEC option is used). • The handswitch (if used) and the cables connecting this to the console. 2. Open the generator cabinet and examine the unit for any visible damage: missing or loose ground connections, oil leaks, damaged cables etc. 3. Ensure that there are no obstructions blocking the ventilation holes or louvers on the generator cabinet.
Every 5 years:	Replace the lithium battery on the CPU board in the control console.

CLEANING

- Never use anything other than mild soap and water to clean plastic surfaces. Other cleaners may damage the plastic.
- **Never use any corrosive, solvent or abrasive detergents or polishes.**
- Ensure that no water or other liquid can enter any equipment. This precaution prevents short circuits and corrosion forming on components.
- Methods of disinfection used must conform to legal regulations and guidelines regarding disinfection and explosion protection.
- If disinfectants are used which form explosive mixtures of gases, these gases must have dissipated before switching on the equipment again.
- Disinfection by spraying is not recommended because the disinfectant may enter the X-ray equipment.
- If room disinfection is done with an atomizer, it is recommended that the equipment be switched OFF, allowed to cool down and covered with a plastic sheet. When the disinfectant mist has subsided, the plastic sheet may be removed and the equipment be disinfected by wiping.

X-RAY TUBE DATA 8

The following pages contain data for the X-ray tube(s) used with your X-ray generator at the time of installation.

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NOTE TO INSTALLER:

INSERT TUBE DATA HERE.

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